Supplement to:

Sea ice as a source of sea salt aerosol to Greenland ice cores: a model-based study

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1. Summit aerosol data processing

Summit aerosol data from 2003-2006 AD are used because [Na] is not reported for other years. These data have low temporal resolution, particularly during winter when difficult weather conditions meant sampling was not always possible. Aerosol was collected on 8 impactor stages. We screened the data for each stage by removing data point > 2*standard deviation above the mean. Data for the 8 stages were then combined, resampled to monthly, and monthly values were stacked to produce representative monthly means. No uncertainty bars on Fig. 3 because some monthly mean values reflect data from only one year. Summit aerosol [Na] displayed on Fig. 3 are within the range of past measurements reported by Mosher at al. (1993) (mean 0.0043 μg m^{-3}).
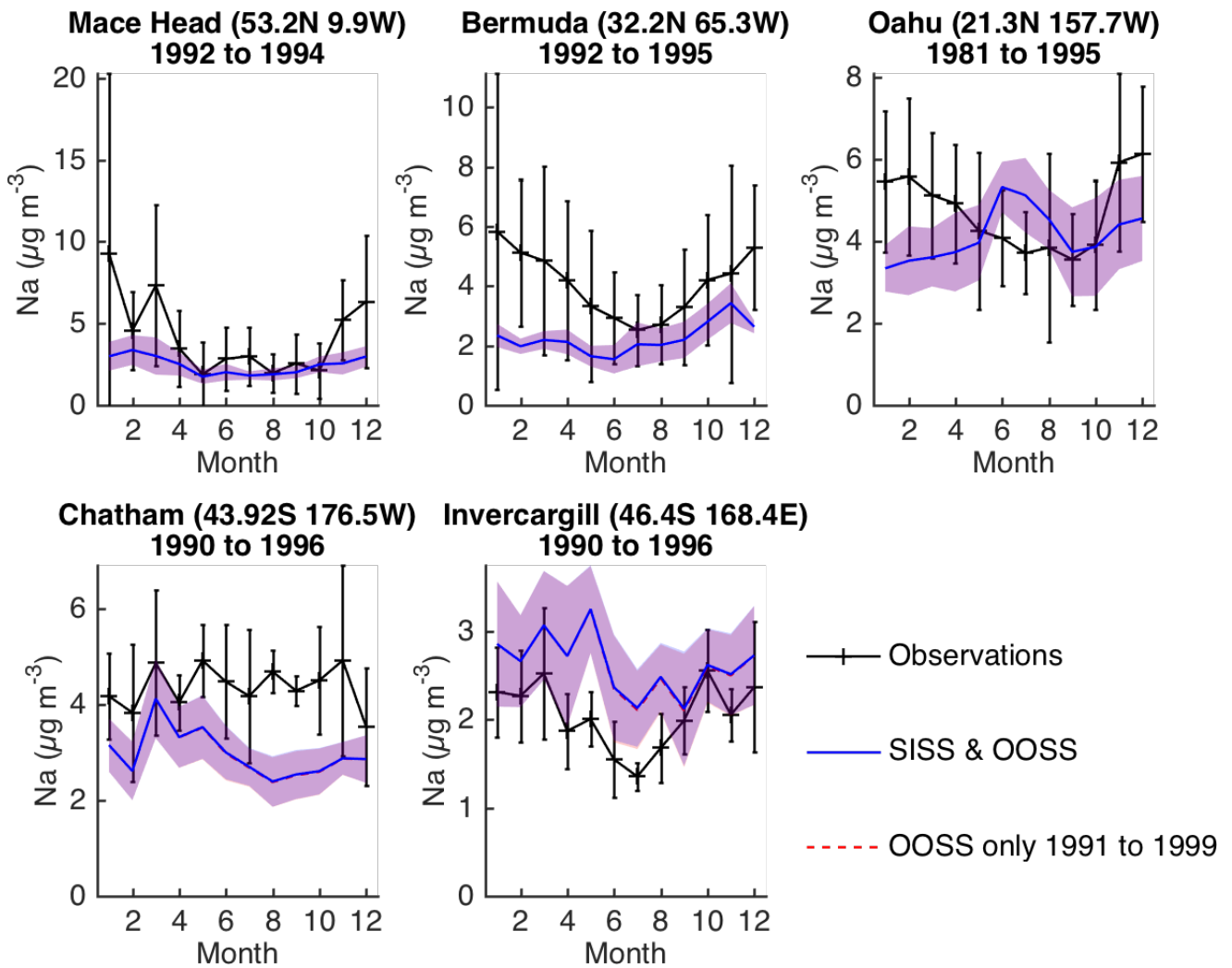
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Figure S1. Sea salt Na aerosol concentrations simulated by p-TOMCAT for 1991–1999 AD compared to observations at coastal low- and mid- latitude locations. Observations and model results are mean monthly values ± 1 σ. Aerosol observations are from the <u>AEROCE-SEAREX</u> network (Savoie et al., 2002).
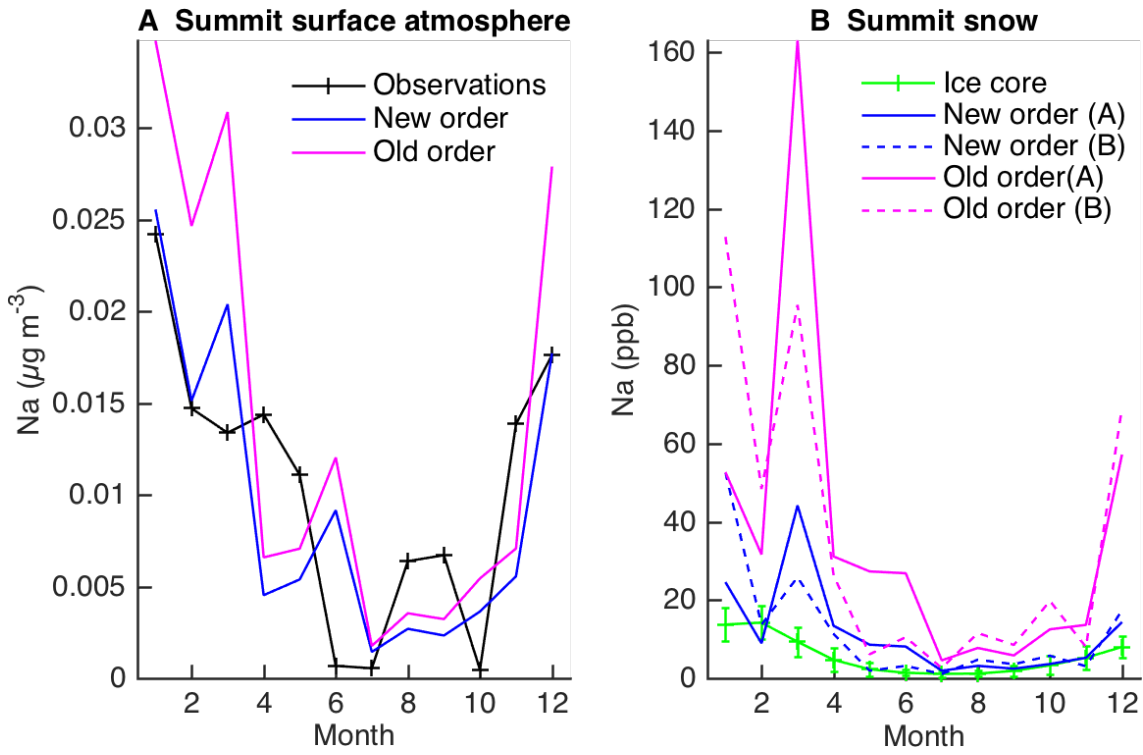
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Figure S2. Effect of changing the order of events in p-TOMCAT from deposition-emissions-mixing (old order) to emissions-deposition-deposition (new order) on [Na] concentrations of the surface layer of the atmosphere (A) and snow (B) at Summit, Greenland 1997 AD. On panel B two different options for simulated sea salt concentrations are displayed: A) [Na] calculated using p-TOMCAT precipitation output in Eq. (5), B) [Na] calculated using ice core constant annual accumulation rate (Table 1) in Eq. (5).
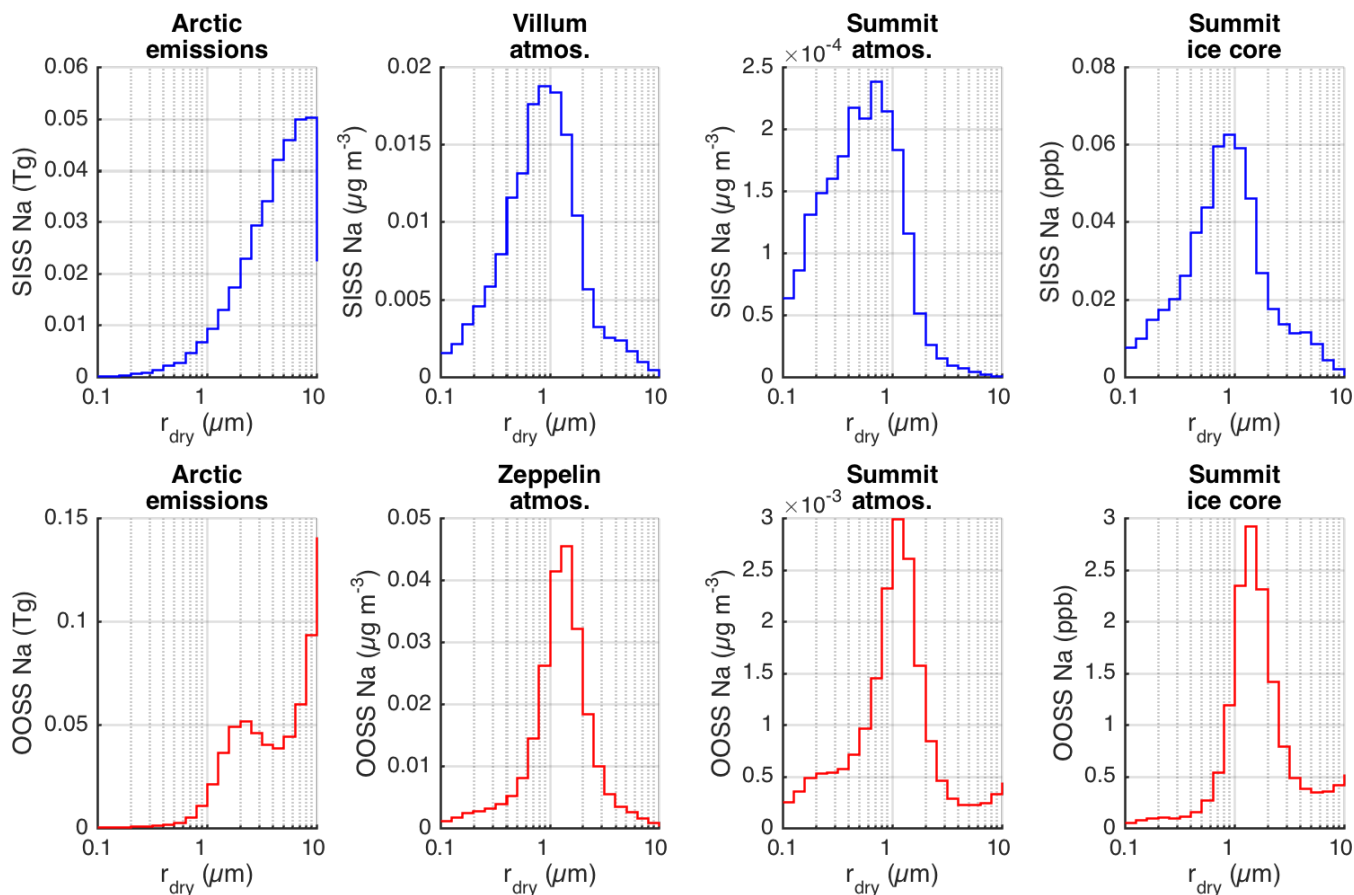
Figure S3. Particle size spectra of SISS (blue) and OOSS (red) when emitted compared to size spectra of sea salt particles in the surface atmosphere at coastal (close to sea ice or open ocean: Villum and Zeppelin) and inland (Summit) locations, and size spectra of sea salt particles deposited on Greenland ice sheet. All spectra represent mean values of DJF 1997 AD.
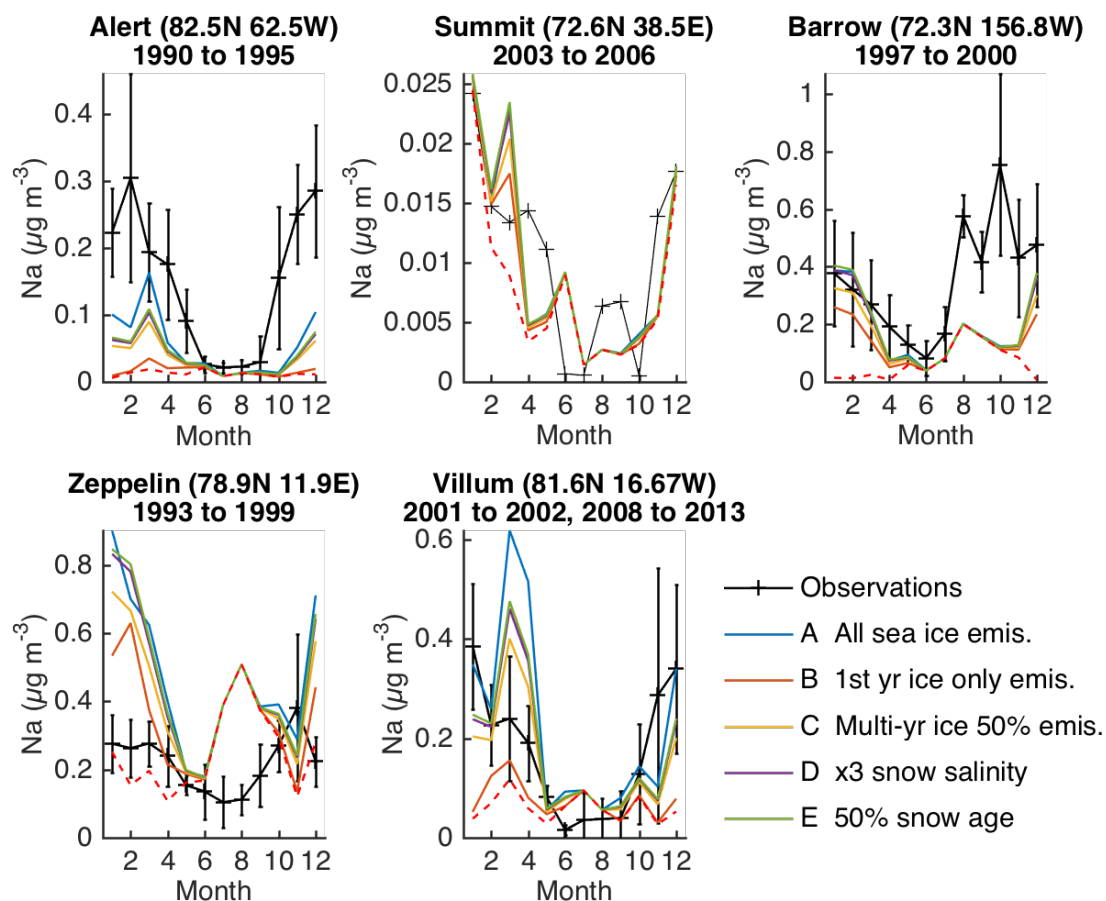
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Figure S4. Results of sensitivity tests to investigate the impact of changing parameters associated with SISS emissions in p-TOMCAT. OOSS contribution remains constant for each test (dashed red line).
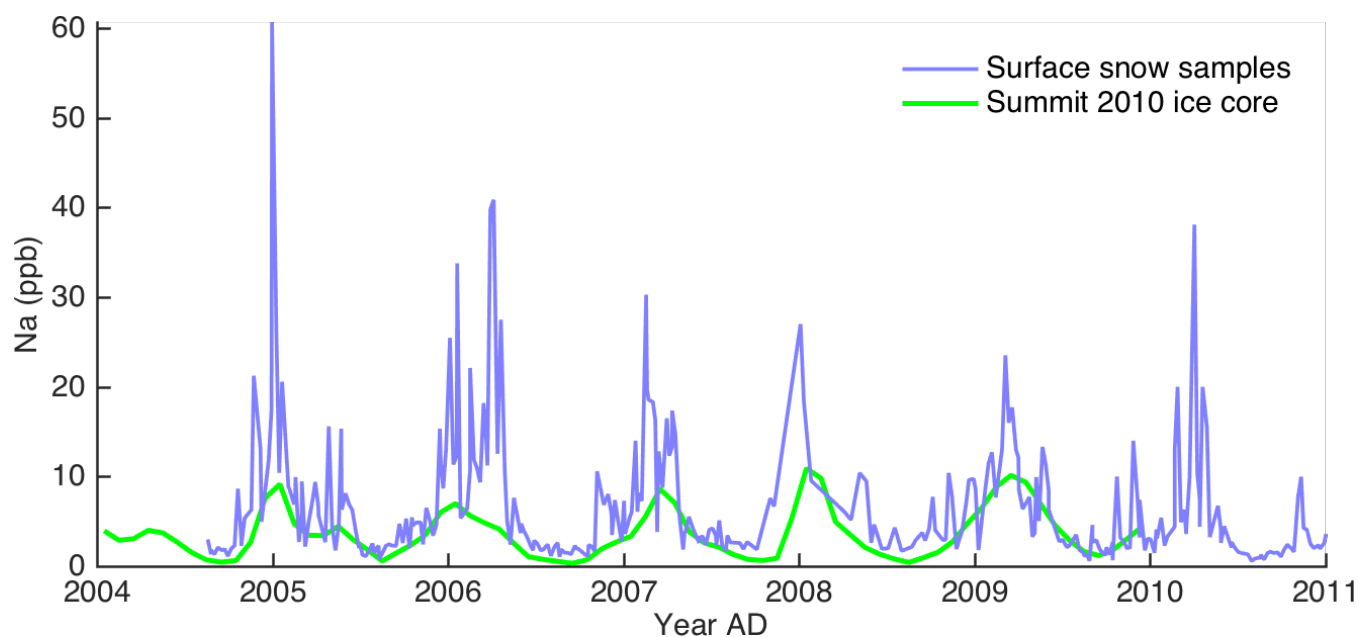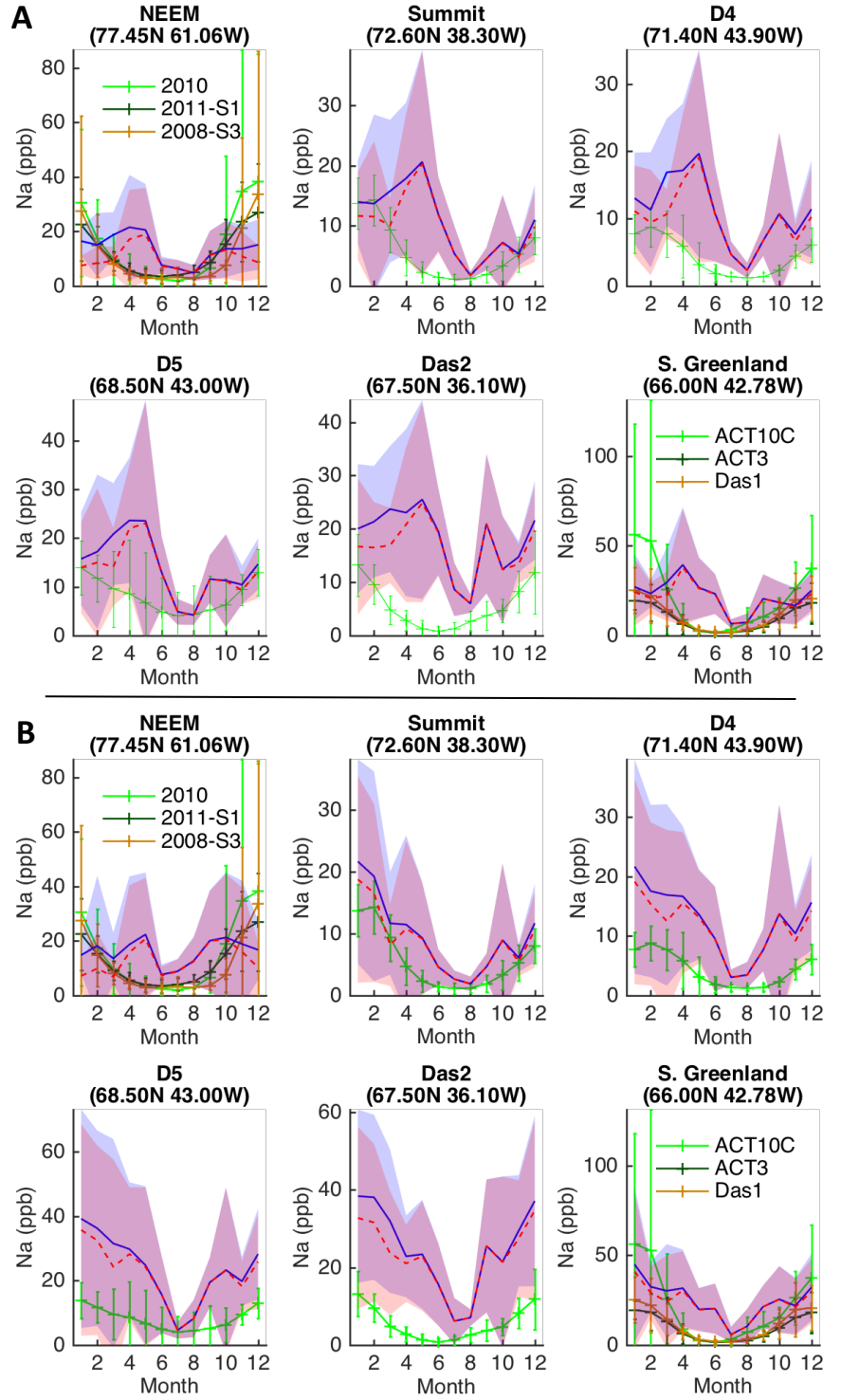
Figure S5. Comparison between Na concentrations measured in surface snow collected weekly at Summit, Greenland, and Na concentrations measured in the Summit2010 ice core for the same time interval.

Figure S6. Monthly mean sea salt Na concentrations simulated by p-TOMCAT for 1991–1999 AD compared to Greenland ice core data. Data are identical to Fig. 5, but p-TOMCAT simulations have not been smoothed prior to stacking. Two different options for simulated sea salt concentrations are displayed: A) [Na] calculated using p-TOMCAT precipitation output in Eq. (5), B) [Na] calculated using ice core constant annual accumulation rate (Table 1) in Eq. (5). In each case, the mean monthly ice core Na concentrations (green) are shown with uncertainty bars denoting ± 1 σ of the inter-annual variability. Model simulations for OOSS only (red dashed line) and the combined OOSS and SISS simulations (blue line) are shown with uncertainty envelopes (red and blue shading), representing ± 1 σ of the simulated inter-annual variability. For two ice core locations, three different ice core records are plotted, as indicated by the legend.

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STable 1. Inter-annual variability of [Na] in ice cores compared to simulated values for 1991-1999 AD. Coefficients of determination (R^2) indicate the proportion of the inter-annual variability of the ice core record that can be explained by p-TOMCAT. Statistically significant values ($p < 0.05$) are in bold type. Negative correlations are indicated by n/a.

Ice core	[Na] using p-TOMCAT accumulation rate			[Na] using ice core accumulation rate		
	Annual mean [Na]	Annual max. [Na]	Inter-annual diff. in annual mean [Na]	Annual mean [Na]	Annual max. [Na]	Inter-annual diff. in annual mean [Na]
Tunu	n/a	n/a	n/a	0.20	**0.29**	0.46
NEEM-2011-S1 **	0.15	n/a	0.17	0.11	n/a	0.40
NEEM-2008-S3 **	0.29	**0.58**	0.18	0.04	0.11	0.09
NEEM-2010-20m **	n/a	n/a	n/a	n/a	n/a	n/a
Summit	**0.54**	**0.43**	**0.62**	0.00	0.04	0.00
D4	0.09	0.04	0.20	0.06	0.27	0.33
D5	0.01	n/a	0.00	0.09	n/a	0.14
Das2	n/a	0.05	n/a	0.00	0.34	n/a
Das1*	n/a	n/a	n/a	n/a	0.02	0.02
ACT10C*	n/a	n/a	n/a	n/a	n/a	n/a
ACT3*	n/a	n/a	n/a	n/a	n/a	n/a
ACT2***	0.03	n/a	0.03	n/a	n/a	n/a
ACT11d***	n/a	n/a	0.01	n/a	n/a	n/a

5   * same grid square in p-TOMCAT

** same grid square in p-TOMCAT

*** same grid square in p-TOMCAT

Additional references

Mosher, B.W., Winkler, P., Jaffrezo, J.-L., 1993. Seasonal aerosol chemistry at Dye 3, Greenland. Atmospheric Environ. Part Gen. Top. 27, 2761–2772.

Savoie, D.L., Arimoto, R., Keene, W.C., Prospero, J.M., Duce, R.A., Galloway, J.N., 2002. Marine biogenic and anthropogenic contributions to non-sea-salt sulfate in the marine boundary layer over the North Atlantic Ocean. J. Geophys. Res. Atmospheres 107, 4356. doi:10.1029/2001JD000970

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